Bell Laboratories Record

Volume one January, 1926 *Number five*

Carrier-Current Telegraphy

By John H. Bell

ALMOST a hundred years ago LeSage of Geneva suggested a system of telegraphy in which 26 wires were required, one for each letter of the alphabet. At the receiving end of each wire were hung two pith balls and when an electric charge was applied at the distant end of the wire, the pith balls moved apart. Each pair of balls represented a letter of the alphabet, and they were suspended in a row in alphabetical order, so that it required the eye of a xylophone player to follow their motions. No records exist as to the speed of transmission, but it would be safe to assume that it did not exceed five to ten words per minute.

A few years later a step forward was made. Another inventor, De Heer, a Hollander, proposed to effect a large saving in wire mileage by using only ten wires. At the sending end there was little change suggested except that electric charges should be sent over two or more wires simultaneously. Here we see the introduction of a code. At the receiving end an important improvement was made. The plan was to have the ten fingers of the hands resting on ten little metal plates connected to the ten line wires. If the operator got a shock in the little finger of his left hand, he said "ah"; if on his little finger of his right hand, he said "eh," and if in all fingers simultaneously, he said "oh"!

So far, I have been unable to find that either of these systems was ever put to practical use. They do show, however, the state of the art of telegraphy a few years after the Napoleonic wars.

Then came Morse, about 1832, with his simple type of instrument and code. Apart from improvements in the design of the instruments used, little advance was made in the art until 1854 when Gintl, an Austrian, proposed a scheme for sending a message in each direction by means of the duplex balance. The duplex circuit and the development of its balancing network has already been described in the RECORD, for September, 1925, in an article on "The Artificial Line." The Gintl scheme, however, could not be used except on rather short lines until, in 1862, Stearns and Varley, as was told in the reference just cited,

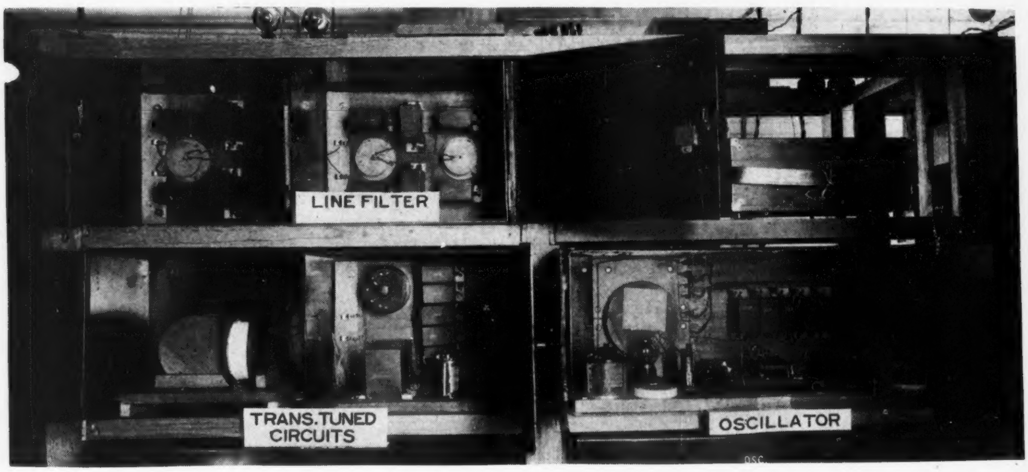
made improvements in the artificial line. The carrying capacity of the duplex was probably in the neighborhood of fifty words per minute. About twelve years later, Edison produced the quadruplex, by means of which it is possible to transmit simultaneously two messages in each direction, i.e., four messages over one wire.

In France, Baudot was engaged in increasing the number of transmitting channels over a single wire, but in order to do so he introduced a new telegraph code and printing telegraph apparatus designed for that code. Although at first he provided only four channels, later developments increased this number to six. About 1908, Booth of London applied the duplex principle to the Baudot system, thereby making it possible to obtain twelve channels over one circuit.

And now we come back home again where developments in our own Laboratories during the last ten years or so have made it possible to obtain twenty-four telegraph channels and one and one-half telephone* circuits over one open-wire pair. If to these channels is applied the Baudot principle of multiplex printer operation, it is possible to transmit eighty-eight telegraph messages and one and one-half telephone conversations over a single pair of wires. Since each telegraph message can be printed at the rate of forty words per minute, there results a total of 3,520 words per minute. Truly a remarkable increase!

The work of these early pioneers is recorded in most of the older textbooks on telegraphy. Our interest in this article is in the more recent developments which have been carried on in our Laboratories in cooperation with the engineers of the American Telephone and Telegraph Company.

Soon after the early work on carrier telephony, described in the last issue of the RECORD, a study was begun of the application of carrier methods to provide additional telegraph facilities



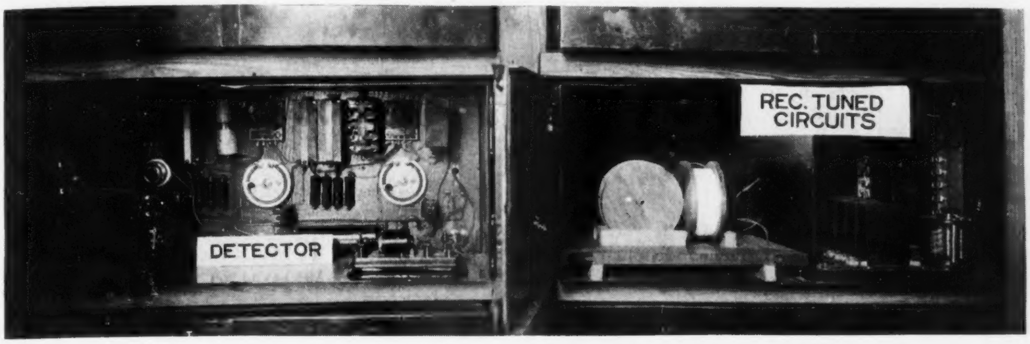
For the experimental installation of high frequency carrier telegraph at Maumee the apparatus was installed in steel boxes. This illustration shows the sending apparatus

**The phantom circuit formed by using two pairs of conductors, each pair to act as a single conductor, furnishes a third telephone channel of which we assign one-half credit to each pair.*

over open-wire circuits. This led to the preparation by P. H. Pierce and O. A. Pawlick (now Long Lines), of an experimental carrier-telegraph system by which four duplex telegraph channels were provided over a single circuit, using carrier frequencies of five, six, nine, and ten kilocycles. Like the original carrier telephone, this depended, for two-way operation, on the balancing of the impedance of the open-wire line at the carrier frequencies by means of an artificial line or network. This experimental apparatus was set up at Maumee and Chicago in September, 1917; and in its test the Laboratories engineers cooperated with the engineers of the American Telephone and Telegraph Company. The system included, at South Bend, a carrier-current repeater in which for each direction of transmission a single amplifying circuit repeated all the messages. The experimental tests were followed by commercial operation with satisfactory results.

About the beginning of 1919, preparations were made for the installation of a carrier-telegraph system between Harrisburg and Chicago with intermediate terminals at Pittsburgh. Ten two-way telegraph channels were provided over a single circuit, in addition to the usual channels for telephony and for ordinary telegraphy.

The messages were carried on currents of twenty frequencies between 3,000 and 11,000 cycles. Each one-way transmission had its own carrier frequency and adjacent frequencies were used for transmission in opposite directions. The outgoing and incoming currents at each end were separated in part by the use of a balanced circuit, including a network to balance the impedance of the line. The apparatus was mounted on unit racks, some of which are shown in the picture of part of the Pittsburgh installation. Among the Laboratories engineers who worked on this system were G. C. Cummings, N. H. Slaughter, M. B. Long, A. J. Eaves, J. B. Harlow (both now in the Western Electric), H. J. Vennes (now in the Northern Electric), and L. W. Wickersheim (now with the Pacific Telephone Company).

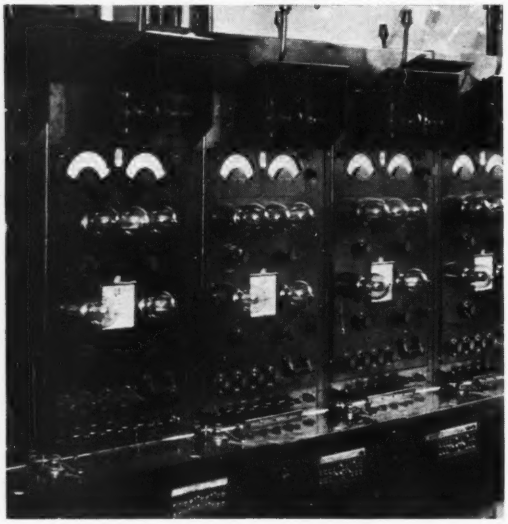


The receiving apparatus for the experimental installation at Maumee

Following the success of this system, the so-called Type "A", a number of similar carrier-telegraph systems were installed. These systems were arranged for directional grouping of frequencies, using eight frequencies between 3,600 and 5,500 cycles for the transmission of messages in one direction, and eight frequencies between 6,500 and 10,000 cycles for the opposite direction.

After several of the Type "A"

carrier telegraph systems had been installed, the American Telephone and Telegraph Company decided to equip the transcontinental line from Chicago to San Francisco. A number of improvements incorporated in the system at this time were embodied in all future sets and the new system



Part of the Type A carrier telegraph terminal equipment at Pittsburgh

then became known as the Type "B." This system provides ten two-way transmissions, one way on frequencies of 3,000 to 5,500 cycles and the opposite way on 6,500 to 10,000 cycles. The apparatus for these transcontinental circuits was manufactured at Hawthorne, where J. C. Burkholder, F. G. Gardner (now Long Lines), and J. S. Jammer assisted in its test. These engineers, and R. W. Chesnut, also cooperated with the engineers of the American Telephone and Telegraph Company and associated Companies in the installation and testing of the system along the transcontinental route.

Numerous other carrier-telegraph systems have been installed since the development of the Type "B" as will be seen from the chart of carrier-telegraph systems. One of the more interesting of these is that applied to the Key West-Havana cables, which were opened for service in April 1921. These carrier circuits provide an additional telegraph channel on each of the three cables and the possibility of increasing the facilities by the addition of others. Because of the high attenuation at the upper carrier-telegraph frequencies, there is a limit to the number of telegraph channels which can be obtained over the cable circuits.

In the meantime other advances in electrical communication imposed upon carrier-telegraphy new problems. Small-gauge cables came into use for long distance telephony, of which the New York-Chicago cable described in the October RECORD is one illustration. These upset the ratio between telegraph and telephone facilities. Whereas on open-wire lines by former methods three telephone and four duplex telegraph circuits can be obtained from two two-wire circuits, in the new cable system it is possible to obtain, in addition to the three telephone-circuits, only two duplex telegraph-circuits. This, together with other requirements, led to the development of another carrier-telegraph system, the "voice-frequency" carrier.* Equipment for its field trial was installed between New York and Pittsburgh and put into commercial operation in the fall of 1923. Four additional systems have since been manufactured and are now in service between New York, Pittsburgh, and Chicago.

The name of "voice frequency" was

**The technical description of this development was presented before the A.I.E.E. in 1925, in a paper by B. P. Hamilton, H. Nyquist, M. B. Long, and W. A. Phelps. Related developments were at the same time presented in a paper by J. H. Bell, R. B. Schank and D. A. Branson.*

given because the range of frequencies normally used for voice transmission is that employed for these telegraph channels. The system is designed for operation on four-wire telephone circuits in cable.* Making no change in the intermediate apparatus of such a four-wire circuit, the telephone apparatus at the terminals can be removed and the carrier-telegraph apparatus substituted. The system thus displaces the telephone to provide telegraph facilities. Ten duplex telegraph channels are thereby obtained over medium-heavy-loaded four-wire circuits, or twelve duplex channels over extra-light-loaded circuits.

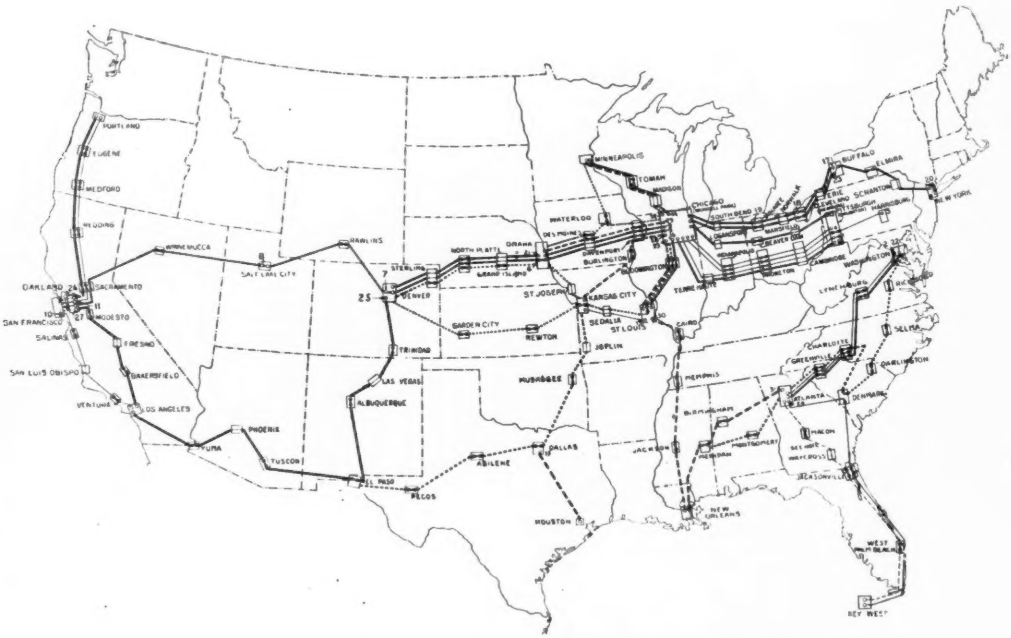
The source of alternating current power for the carrier current is a multi-frequency generator which furnishes enough energy to feed twenty separate systems radiating from the same office, or a total of 240 one-way channels. The lowest frequency is 425, and the separation between frequencies is 170 cycles, making the twelfth frequency 2,295. Actuation of a telegraph key, or other suitable sending device, cuts off the carrier frequency intermittently so that short or long spurts of a.c. simulating dots and dashes are sent out. This is, in effect, modulating the carrier frequency by the operating telegraph frequency. These spurts of current pass through the sending filter and mingle with the currents from other channels, and all are transmitted over the line as a resultant composite current. At the distant end, the currents encounter the receiving filters, which separate them into their original entities, each band-filter allowing a single modulated carrier current to pass but excluding all others. After passing through the filter, the currents are amplified, then rectified, and the rectified currents made to actuate a relay. From that point, the signals are of the common or garden variety, so that carrier channels can be extended to any other type of telegraph system. For example, a circuit between New York and San Francisco could be made up by connecting together one channel of a voice-frequency carrier-telegraph system between New York and Pittsburgh, one channel of a high-frequency carrier-telegraph system from Pittsburgh to Chicago, ordinary open-wire composited-circuit telegraph from Chicago to Denver, and then for instance a channel of a high-frequency carrier-telegraph system from Denver to San Francisco.

Voice frequency carrier telegraph terminal equipment at Pittsburgh

On a carrier circuit of such length as New York to Chicago, it would be possible to obtain on each channel the speed of transmission which would enable a quadruple multiplex printer to be used, thereby providing four separate transmissions per channel or forty-eight transmissions for a twelve

**This system for "Telephone Transmission over Long Cable Circuits" is described in a paper under this title. A.I.E.E. Vol. XLII by A. B. Clark.*

channel carrier. In addition, the ordinary telegraph circuits, obtained by compositing, can be operated simultaneously with the voice-frequency carrier, thereby providing two more signal channels in each direction over the two cable pairs. The rate of operation over these channels however is not as high as over the carrier channels and would enable only two printers per channel to be operated as against four printers per carrier channel. This, however, would add four more printer channels, making fifty-two printer channels in each direction, or a total of 104 printer channels over one four-wire circuit. This is equivalent to twenty-six channels or messages per wire, whereas, as I pointed out at the beginning of this article, LeSage proposed to use twenty-six wires to transmit one message. The total improvement in message capacity is thus $(26)^2$ or 676 times.



Routes and locations of carrier telegraph systems, present and proposed

Although we may, in the fullness of our greater knowledge, smile at these early efforts, still we are indebted to many of these pioneers of an earlier age for a little something which we have extracted from their achievements and adapted to our structures of today. Perhaps it will not be many years before posterity indulges in a kindly smile at our own efforts.

An Engineering Career

By E. H. Colpitts

A note of appreciation of the scientific and engineering work of Harold W. Nichols

AS ONE intimately associated with Dr. Harold W. Nichols during the eleven years in which he was active in the research and development work of the Bell System as a member of the Engineering Department of the Western Electric Company, Inc. (now the Bell Telephone Laboratories, Inc.), I welcome the opportunity of recording a few words appreciative of his work as an engineer.

Harold W. Nichols

He entered the work of the Western Electric Company in 1914, at a period standing out as one when new tools and new methods applicable to communication were being found and applied. The first commercial applications of vacuum tubes in telephone repeaters were being made; and in this device, and in the application of the more complete theory of electrical circuits then becoming available, radically new developments were foreseen in the fields of radio and carrier-current systems, as well as in applications to voice-frequency telephony. He entered upon his work with training, initiative, imagination, and personal characteristics fitting him not only to carry on investigational work himself but also, as soon appeared evident, to undertake direction of the work of others. In no respect did his performance disappoint those broadly responsible for the work with which he was connected.

His personal contributions to the development of the communication art can to a slight degree be measured by the fact that twenty-one United States patents were issued to him and some eight applications are still pending. These patents cover important elements of carrier currents and radio.

Through his papers on scientific and technical subjects, as well as through his personal contacts, he was well and favorably known in the scientific and technical world. When in February, 1923, he delivered an address before a meeting of the British Institution of Electrical Engineers at London on the Methods of Transatlantic Telephony, he was awarded by the Institution the Fahie Premium. He served for some years on the Board of the Institute of Radio Engineers; and just prior to his

death he had been nominated as one of the candidates for President of that Institute.

What promises to be a basic contribution to the theory of propagation of electric waves in radio is contained in his most recent paper, a joint publication with J. C. Schelleng, in which the authors discussed the effect of the earth's magnetic field upon radio transmission.

As I view his career, however, important as were his own personal contributions, his greatest contributions were indirect, in the guidance and stimulus which he gave to the able group of engineers and scientists who in our functionalized organization looked to him for broad general direction. The contribution of this group to the fields of communication employing high-frequency currents ranging from voice frequencies up to the frequencies in "short wave" radio have been of the greatest importance and underlie much of the art today. To attempt a discussion of this, however, would too greatly expand this note.

He was recognized as an authority in electrical theory, and his advice and suggestions were highly valued and appreciated. Very generously he made himself always available to his colleagues as a consultant on problems which arose in connection with their work in lines outside of his own particular activity.

I cannot conclude this brief and general note without expressing the deep sense of loss which I know is felt by the whole group who in the Laboratories and in the American Telephone and Telegraph Company were associated with Dr. Nichols. In the relatively few years of his engineering career, he won a position attained by few men, even of those to whom many more years of activity have been allotted.

Our Budget

By A. O. Jehle

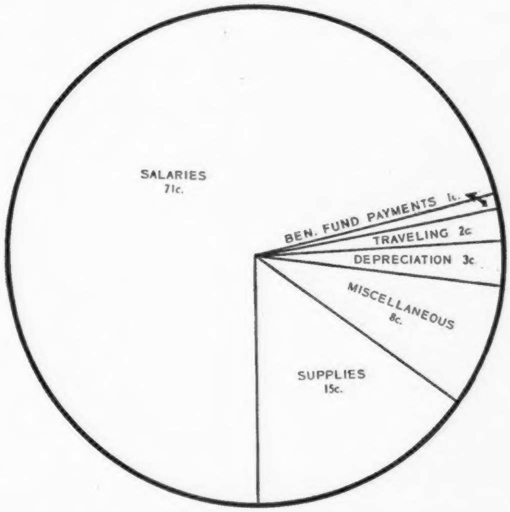
DURING 1926 the Laboratories will expend a very considerable sum, millions of dollars, in carrying on the work with which it is charged. Authority to spend this money* will arise from the action of its Board of Directors in the approval of a budget of expenditures; and with this approval our executives may proceed with their working program for 1926 and know definitely what expense may be incurred.

Budgeting is an essential of modern business administration. In our Laboratories a budgetary procedure is required to coordinate the activities of the various functional departments and to serve as a basis for centralized executive control. The budget which our Directors will approve for 1926 will be presented to them by the President, and represent the summarized reports of anticipated expenditures prepared and estimated by the departmental heads. The individual departmental estimates of expense, classified by the kinds of work involved, will be consolidated into a

*"*Who Pays our Salaries" in the October Record, p. 62, tells where this money comes from.*

Company budget by the Statistical Department. This budget, after approval by the Executive Vice-President, is forwarded to the President for his consideration and approval and subsequent consideration by the Directors.

The budget for the Laboratories, as prepared by the Statistical Department, summarizes the operating expense for the entire year and also the expenditures to be met in plant and equipment. A knowledge of plant expenses for the year is necessary for the preparation of the budget of operating expense, since the latter must include the additional depreciation corresponding to the recently added plant and equipment.



How each dollar of operating expense is divided. "Miscellaneous" includes interest charges, benefit fund reserve, rentals for property other than West Street, etc.

It is the budget of operating expense, however, which from the standpoint of the laboratory engineer is most interesting and important. This determines the total salaries which may be expended and the value of supplies and shop work which may be obtained for carrying on our research and development activities. This operating-expense budget is prepared on two bases: in one the proposed expenditures are classified as to type of expense, and in the other as to type of work.

In obtaining the data on which to make its budgetary conclusions the Statistical Department, in the late autumn, requested from the heads of the various functional departments of the Laboratories the probable expense for their departments for the coming year in terms of (a) salaries, (b) supplies and outside shop work, (c) traveling, and (d) miscellaneous. The first two of these groups represent by far the major part of our expense. In fact, salaries alone are almost three-quarters. "Supplies and outside shop work" cover the cost of materials and supplies withdrawn from the storerooms, or purchased from the Western Electric Company or outside suppliers. It covers the material with which our scientists and engineers work. Under miscellaneous expense, as estimated by the department heads, are such items as outside rentals—for example, the space occupied by the Tube Shop at Hudson Street—and other expense like express and freight charges.

In arriving, however, at the total operating-expense budget the Statistical Department includes in addition to these items, as estimated by the department heads, several others. First among these is depreciation and outside repairs. This expense arises from the fact that plant items, such as buildings, permanent fixtures, machinery, and furniture cannot be kept in service indefinitely but must from time to time be replaced or retired. It is recognized as sound business practice

to set aside each year reserves against such plant depreciation. Therefore, the cost of such plant should be distributed as evenly as may be throughout the service life of the property.

Another item which is included in the operating-expense budget is the payments made to employees for pensions, sickness, accident, and disability, in accordance with the provisions of the Benefit Plan of the Company. It is interesting to note that these are not included as salaries although they enter into the total budget.

There is presented then to the Board of Directors a budget for our Laboratories as a whole, classified as described above and giving the total operating expense for the year. Although this covers the total expense it does not tell the kinds of work proposed and the expense involved in each kind. With the formation of our Laboratories the first of last year, there was set up an entirely new classification of expense, by kinds of work. The Laboratories' work is estimated on an annual basis and is grouped for statistical summaries in so-called "executive control classifications," such for example as "Transmitters, Receivers and Induction Coils," "Wire Transmission Systems," "Research and Development of General Application," and "Exchange Systems and Apparatus."

For any proposed expenditure of the Laboratories, as expressed in kinds of work, there corresponds an equal proposed expenditure in kinds of expense. Suppose, for example, that all the engineers and scientists in the Laboratories were to be engaged on a single one of the executive control classifications of work, for example, "Transmitters, Receivers and Induction Coils." The cost of this piece of work would then include all building expense, heat, light, service, and the like as well as all other expense of a clerical and commercial nature. Since, however, there are several different types of work, each of them must bear its proportionate part of this general expenditure. The Statistical Department, therefore, advises the heads of the functional departments as to the proportion of such general expense with which their departments will be charged as a result of their departmental requirements for floor space, telephone service, and the like. With this information in hand the department heads are able to estimate the expense which will be met by their departments in each of the types of work with which they are concerned. These estimated expenditures, by types of work, are then summarized and their total is, of course, equal to the total budget by kinds of expense.

A Binder for the Record

Those who wish to preserve a permanent file of the RECORD may secure through the Personal Purchase Department a binder of the same style as that used for the technical reprints.

Electro-Mechanical Sound Recording

By Joseph P. Maxfield

AT the time of its formal introduction to the public, the new method of sound reproduction developed in our Laboratories was outlined by the RECORD.* As was there noted, to take full advantage of the new apparatus records of equally high quality must be used. Since the technique of making these records has been developed in our Laboratories, it is felt that an account of the general features of the problem and its solution will prove of interest.

Before considering the methods involved it may be well to make a rough division of the problem into its component parts. A first consideration is the character of the sound which is to be recorded, including the effects of reverberation and general studio design. The storing or recording of sound requires first a mechanical system which will respond faithfully to sound waves. There is also required some material in or on which this sound may be recorded, and an intervening electro-mechanical system which permits the sound waves to make the record in this material.

Studio Acoustics Important

In recording work, therefore, one of the important factors deals with the acoustics of the room in which the recording is done. It is probable that the most comprehensive single factor in this connection is the time of reverberation, i.e., the time taken for a sound of given intensity to die away after the source has been stopped. Experiment has shown, however, that the shape of the room and the position in which the curtains and other absorbing materials are hung play a part in the excellence of the music. By a proper control of the acoustic properties of the recording room, it has been possible to record the so-called "atmosphere" surrounding the music. When this result has been accomplished, the listener seems to "feel" the presence of the artists to whose record he is listening.

Effects of Damping

If a studio is too highly damped or as a musician would say, "too dead", all of the instruments lack the vibrant, ringing tone which lends life and spirit to the music and to which we are all accustomed. The impression on the listener is very similar to that produced by music played in the open air where no floor or sounding boards are provided to reflect the sound. If a room is insufficiently damped, or in the musician's terminology "too live," two effects are produced, both of which are disagreeable. The first is a tendency of one set of notes to blur with those produced immediately before and after; and in the case of large orchestras, blurring is so bad as to make it impossible to pick one instrument from another. The second effect is to leave the listener with the impression that he is listening to music being played in a totally bare and empty room. It is interesting in this connection that the studio must

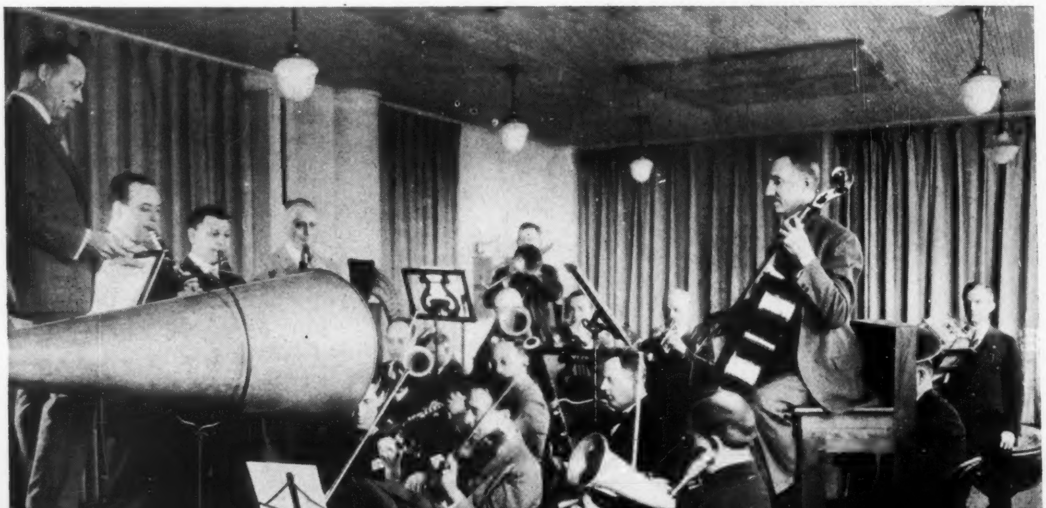
be slightly more damped than the rooms in which we are accustomed to listen to music, because the phonographic process is what we call single channel—that is, it "listens" with one ear only. The effect of slightly too live a room can be produced by stopping up one ear and listening with the other one alone. However, where acoustic conditions are correct, the illusion produced is so good that the reproduction is raised from the class of minor amusement to that of an artistic production.

In the case of large orchestras and similar types of music, the reverberations in the hall or theatre constitute part of the musical and artistic effect. The solution of the problem of recording these effects in such a manner that when the music is reproduced in a living room the effects appear to be those desired, has constituted one of the real advances in the recording art.

The second important factor is the range of notes or frequencies which it is possible to record and reproduce. This subject was covered sufficiently in the RECORD article* mentioned.

In attacking the problem of improved recording methods there are two obvious lines of procedure. The first is to make use of the energy of the sound waves for the purpose of operating the recording instrument. This is the method which has been in use for many years. The second is to make use of high-quality electrical apparatus, associated with vacuum-tube amplifiers, in order to give more freedom to the control of the process. This second method has been adopted because the amount of the energy available directly from the sound to be recorded is so small as to make its use extremely difficult, particularly if the artists are to play or sing in a natural manner. In the case of the weaker instruments such as the violins,

**Bell Laboratories Record, November 1925, page 99.*



To record by the old acoustic method it was necessary to crowd the players close to the collecting horn, and equip some of the violins with special resonators, such as shown in the foreground

it has been possible to use only two of standard construction. The rest of the violins are of the type known as the "Stroh", which is a device strung in the manner of a violin but so arranged that the bridge vibrates a diaphragm attached to a horn. This horn is directed toward the recording horn, as shown in one of the accompanying illustrations. With such an arrangement of musicians, it is very difficult to arouse the spotaneous enthusiasm which is necessary for the production of really artistic music.

The modern recording studio looks very much like that of a broadcasting station with the orchestra grouped in comfortable positions with normal instruments

In the picture showing the new method, the musicians are sitting at ease more nearly in their usual arrangement and all are using the instruments which they would use were they playing at a concert. Furthermore, the microphone is now sufficiently far away from the orchestra to receive the sound in much the manner that the ears of a listener in the audience would receive it. In other words, it picks up the sound after it has been properly blended with the reflections from the walls of the room. It is in this way that the so-called "atmosphere" or "room-tone" is obtained.

In the old process, it sometimes happened that after the instruments had been arranged in such a manner that the relative loudness of the various parts had been balanced correctly, it was found that the whole selection was either too loud or too weak. This usually meant a complete rearrangement of the players. With the flexibility introduced by the use of electrical apparatus including amplifiers, the control of loudness is obtained by simple manipulation of the amplifier system and is in no way related to the difficulties of the relative loudness of one instrument to another. The only problem for the studio director in this case is to obtain the proper balance among the various musical instruments and artists. The advantages derived from this added ease of control are also made manifest in that it is much easier and less tiresome for the artists and it is usually possible to make more records in a given time.

It may be interesting to follow the course of the sound vibrations from the time they are produced until they appear as an irregular groove on the phonograph record. The sound is first picked from the air by means of

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a special telephone transmitter which is essentially an instrument which translates into voltage fluctuations the air-pressure fluctuations which strike its diaphragm. These voltage fluctuations, which are exceedingly small, are

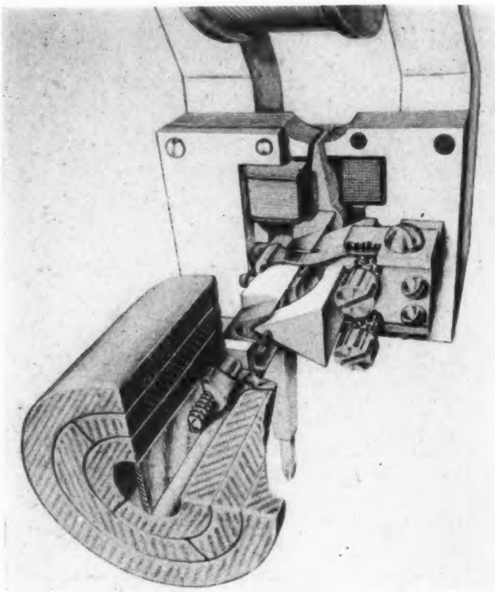


Fig. 1. A sketch of the rubber line recorder

amplified by distortionless vacuum-tube amplifiers until they are of sufficient power to operate the device which cuts the permanent record in the disc of soft wax. This instrument, known as the recorder, is one of the examples of the application of the wave-transmission theory of electric circuits to mechanical systems.

A picture of one of these recording instruments is shown in Fig. 1, while a simplified diagram of its equivalent electric circuit is shown in Fig. 2. In actual practice it has been necessary to take account of some second-order factors which have been left out of this diagram, as they would greatly increase its complexity.

Referring to Fig. 2, the inductance labeled m_1 represents the mass of the armature which when acted on by the magnetic field forms the driving portion of the mechanical system. The condenser c_1 represents the flexibility of the shaft connecting the armature to the stylus holder; m_2 represents the mass of the stylus holder and stylus; c_2 the flexibility of the shaft connecting the stylus holder with the metal piece which fits into the rubber damping element; m_3 the mass of this metal piece; and c_3 and r represent the characteristic of the damping element. The two condensers, shown dotted and unlabeled, represent two of the second order factors mentioned above.

Those who are at all familiar with electrical filter design will immediately see that, providing the two undesignated condensers are omitted, this is a filter of the low-pass type.* In this particular case the filter has three sections and a terminating resistance. In designing mechanical analogues of such a system, the problem presented is three-fold—first, that of arranging the parts so that they form repeated

Bell Laboratories Record, October 1925, page 59.

An up-side-down view of the "rubber line" recorder

filter sections; second, determining the magnitudes of these parts so that the separate sections all have the same characteristics; third, that of providing the proper resistance termination.

The use of the third section and the terminating resistance was decided upon after a considerable amount of experimental work. It was hoped that the resistance of the wax to the back-and-forth motion of the cutting stylus might be used as the terminating resistance. It was found, however, that under the conditions existing in a commercial recording-room, the value of this resistance, even though of a right character, varied so greatly from one wax blank to another as to be unsuitable for the purpose. It is probable also that the value of this resistance is not the same for all notes or pitches lying within the range which it is desirable to record. In the recorder as finally developed, this terminating resistance has been made so large that effect of the wax is negligible in comparison. Practically, therefore, it acts as the complete control element of the mechanical filter.

Such a filter when properly designed will have a response *versus* pitch characteristic which is flat, within practical limits. The actual recorder owing to the presence of the two undesignated condensers of Fig. 2, has a loss of response at the low-pitch end. This loss is unfortunately necessary in order to avoid the large amplitudes which accompany the low pitched notes and which would cause the trace on the record to cut from one groove over into its neighbor. While we have

The amplifier operator in a recording studio has ready control of the overall loudness of the record

no accurate calibration of the older processes of recording, there is considerable evidence to indicate that the fundamentals of notes below middle C were not recorded and that fundamentals or harmonics lying above the middle of

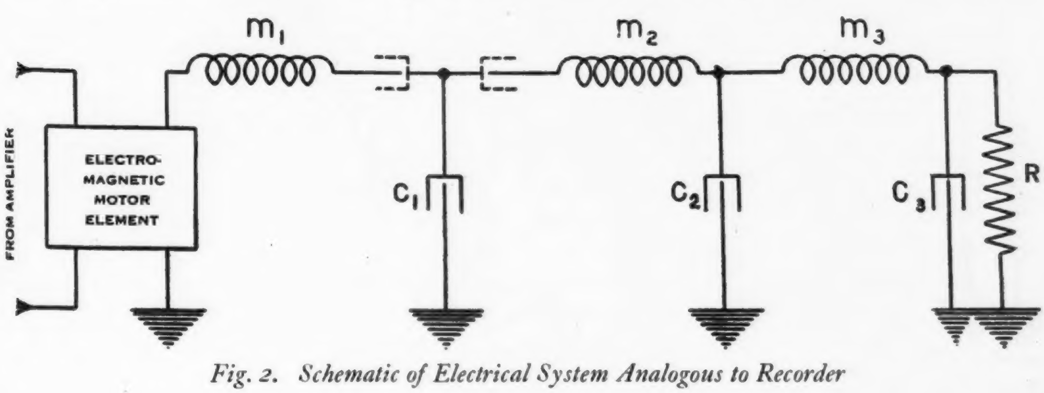


Fig. 2. Schematic of Electrical System Analogous to Recorder

A rubber-line recorder being adjusted by Harry Summers

the upper octave on the piano also failed to record. The loss of the fundamentals of the low notes was largely responsible for the metallic tones which accompanied phonographic reproduction, while the loss of the higher harmonics was responsible for the general muffled quality and the inability to hear the sybilants of speech. In other words, the low range is responsible for the naturalness or what is termed the "body" of the music while the higher harmonics are largely responsible for the details and clarity of the tone.

When this complete range of notes is properly reproduced in conjunction with the proper amount of reverberation effect, it is easy for the listener to imagine himself actually present at the original performance.

The exactness of the sound records produced by this new method has already made something of a revolution in the phonograph art and will permit the application of that art to new fields.

Mechanical Developments at Hawthorne

MANUFACTURE by the Western Electric Company is the stage in the production of communication apparatus which follows its development in our Laboratories and its final specification as a design acceptable to the engineers of the American Telephone and Telegraph Company. In the functionalized division of the creative work of the Bell System it falls to the Laboratories to specify the design—i.e., what shall be made—and to the Manufacturing Department of the Western to determine the manufacturing processes—i.e., how the specified apparatus shall be made. Between the raw materials, such as metals, glass, wood, insulating textiles and compounds, and each finished manufactured article whether telephone cord, coil, transmitter, complete switchboard, or radio broadcasting set, there intervene a number of processes of manufacture, each a step in the evolution of the final form. It is the task of the Development Branch to maintain at the highest state of development these processes and machines so that manufacture will always be carried on at lowest possible costs consistent with a high standard of quality and the best working conditions for the employees. Several hundred engineers and scientists are engaged in fulfilling this task under the leadership of David Levinger, Superintendent of Development. Assisting him and in charge of various

divisions of the work are: R. A. Price, F. W. Willard, J. R. Shea, C. D. Hart, A. H. Adams, H. L. Ward, and F. C. Spencer.

Their work is always a source of interest to their colleagues in the Laboratories. In the first place, for the proper design of commercial equipment the Laboratory engineer needs to be informed of the possible methods and limitations of different manufacturing processes and methods. In the second place, there is the pleasure which he takes in observing development work well done, a finished performance and the accompanying economies.

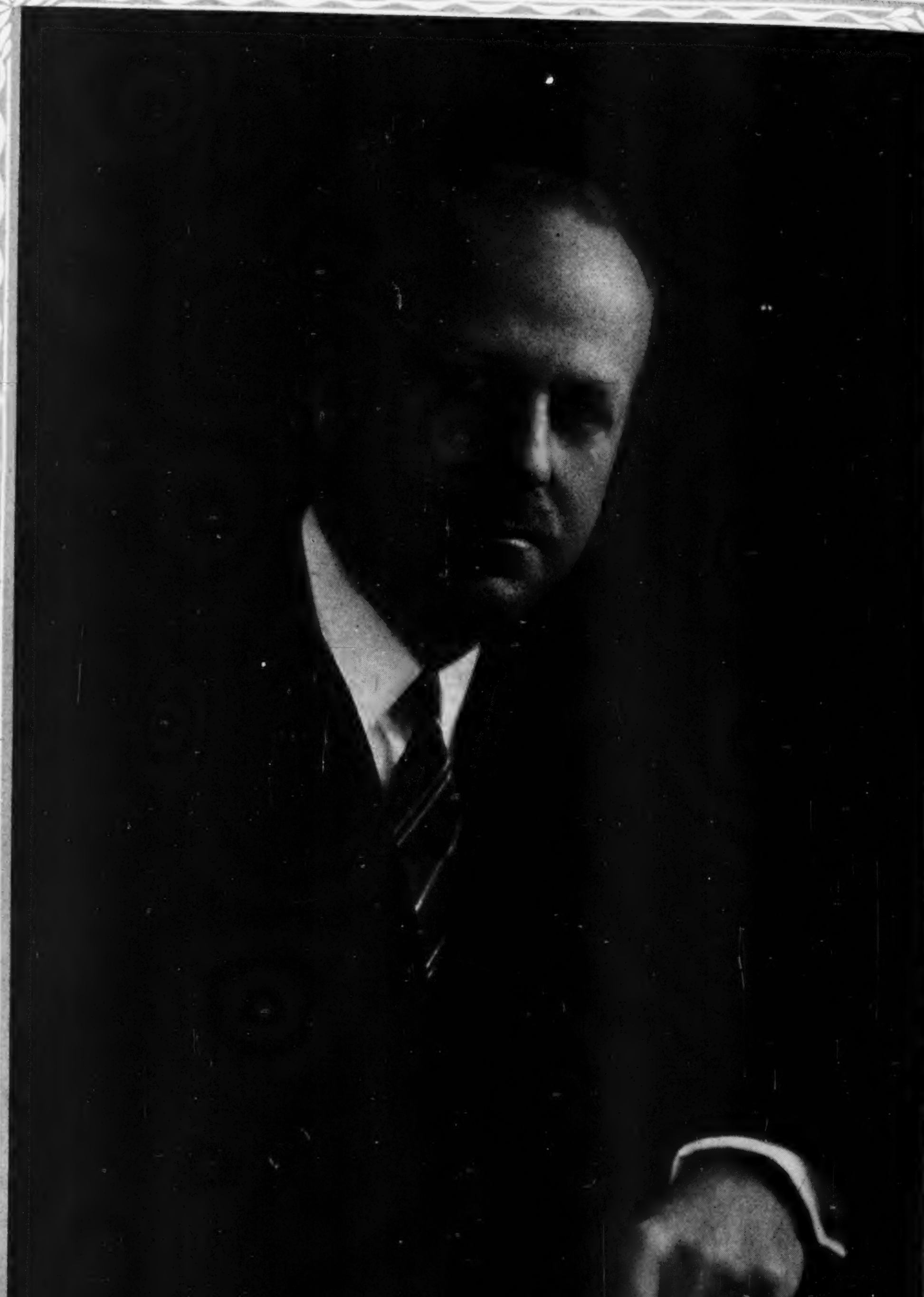
One of the responsibilities of this group at Hawthorne is reduction in cost of manufacture by improvements in methods. Some recent developments in cost reduction were described to members of the Laboratories in a talk by Mr. Levinger upon the occasion of a visit to New York, December fourth and fifth.

His visit to the Laboratories was unexpected, but when he consented to speak our largest classroom (R. 411) was quickly filled with interested engineers who applauded enthusiastically his accounts of recent advances in technique and their resulting economies in cost and human effort. At the request of George B. Thomas, who made the arrangements, Mr. Levinger repeated his talk the next day for another roomful.

Among many matters discussed perhaps the most spectacular was the rod and wire mill which was built at Hawthorne comparatively recently upon plans made by the Development Branch. The rolling of rods and the drawing of wire had become rather definitely standardized processes before this group started its development studies which showed the possibility of more rapid and economical production. Where, for example, the existing plants rolled from billets to one-quarter inch rod with eighteen passes, the new Hawthorne plant started out with sixteen and was soon operating with fourteen passes. Similarly, in the drawing of wire the studies of the principles of wire drawing and the determination of the optimum shape and size for dies resulted in an increase in the speed of drawing fine copper wire from about 700 feet per minute to cover 2000 feet per minute. In addition the plant occupies only from one-quarter to one-third the space that was ordinarily required for the same output. Such improvements

Mr. Levinger explains old and new ways of making transmitter face-plates

in producing one of the necessities of communication equipment mean continuing savings to the Bell System and a source of pride to the colleagues of the Hawthorne engineers.



To the Employees of the Bell System:

This is the season when friendships are renewed and when we like to say the things which are in our hearts but which are usually left unsaid in the rush of busy days.

The spirit of service and the satisfaction which comes from doing useful work is something which can be shared, and I believe, is shared by every individual, young or old, in the Bell System. I know of no other business where the opportunity for service is greater, or where the individual effort of each man and woman counts for more.

We can all be proud of the splendid enterprise in which we are engaged. It is worthy of the best that is in us, and I want to express the hope that, in the year just closing, each of you has found real happiness—that happiness which comes from serving others.

I congratulate you upon the success and happiness that have been, and wish you all greater success and greater happiness in the year to come.

Walter S. Gifford

His First Job

When R. L. Jones came to the Laboratories from Massachusetts Institute of Technology in 1911, our era of scientific research was just getting under way. Mr. Jones had been thinking of hydro-electric power engineering as a lifework. But Dr. Jewett had been one of his instructors; H. S. Osborn, a close friend at Tech, had entered the A. T. & T. a year before; Mr. Shreeve came to Tech and talked to him about telephone research. So on July 31, 1911, after obtaining his Doctor of Science degree, he reported to E. H. Colpitts and was assigned to Mr. Shreeve's group to work on mechanical telephone repeaters. Our present series of numbered laboratory notebooks had just been started and Book No. 8 was assigned to Mr. Jones. Its first entry is a study of the motion of carbon granules in a glass-walled transmitter button. Another project was a magnetostriction element to drive the mechanical repeater. But his most important early contribution was the idea of making accurate quantitative measurements of the mechanical characteristics of vibrating apparatus—such quantities as amplitudes at various frequencies, natural frequencies and damping constants. This investigation was a part of the Research Department's outstanding problem of the day — the development of a telephone repeater.

R. L. Jones

Before long, his associates began to see evidences of the abilities which were to carry Mr. Jones to his present position as head of Inspection Engineering. His interests were those looking to the future; studying the broad aspects of his problems, planning methods of attack, developing men to carry out these plans, and infusing them with his own enthusiasm. Gradually a group was assembled under his supervision, and in 1914 he was put at the head of the Transmission Branch reporting to Dr. Jewett, then Assistant Chief Engineer. As the Engineering Department grew, it finally became apparent that transmission investigations were a logical part of its research work, and Mr. Jones and his group were made a part of the Research Department. Some years later Mr. Jones carried his research point of view into the development of a new department, that of Inspection Engineering.

Early Developments in Telephone Signalling

NATURALLY, the apparatus for transmitting speech-currents and for reproducing the speech are the most vital parts of the complete telephone. Yet there are many indispensable accessories to the telephone, of which one of the most important is the intricate but highly efficient system of signalling.

The simplest telephone system is formed by joining two telephones permanently through a single line consisting of a pair of wires. The next step is a line connecting more than two telephones. In neither of these forms is the question of signalling a very great problem. But the modern conception of the telephone plant, the ultimate aim of which is universal service, is that every line shall connect with some intermediate agency where it can be connected at will with any other line. Were there no means whereby the individual initiating a call could attract the attention of the person at the other end of the line the telephone would be of but little use in any form, nor would a modern exchange be possible could not the caller attract the attention of the intermediate agents who make the necessary connections and so complete the calls. Therefore the matter of signalling is one of prime importance.

Electrical signalling used in connection with telephony may be broadly divided into two classes. The first includes all the methods whereby the central office operator attracts the attention of the subscriber; the other embraces all those signals which are used for the information and the guidance of the operator and enable the modern telephone plant to function smoothly and efficiently.

It is a universal practice to attract the attention of a subscriber by means of an electric bell. Although the electric bell antedates by many years the telephone, various methods of signalling were employed before the bell was associated with the telephone circuit.

Early Signalling Methods

The first outdoor telephone line was between the office of Charles Williams at 109 Court Street, Boston, and his home at Somerville. When Mr. Williams wished to call his home he thumped with the butt of a lead pencil the diaphragm of the instrument which served both as transmitter and receiver. If there was someone close to the telephone at the other end, and if the room was quiet, the tapping noise could be heard. However, it was unreliable at best and the repeated tapping injured the diaphragm and rendered it useless in a short time.

The first commercial telephone user was Russel C. Downer of Somerville, Massachusetts. In May, 1877, service was established between his Somerville home and the banking office of Stone and Downer, Boston. Mr. Downer leased two telephones and connected them with an existing private wire telegraph line.

For signalling purposes the telephones on this line were equipped with the then late development known as Watson's "Thumper." In this device a small hammer was mounted within

Watson's "Thumper"
Number 22 of first series manufactured. The small hammer strikes rear edge of diaphragm when button is pressed

the telephone in such a manner that pushing a button in the front of the box would cause the hammer to thump the edge of the diaphragm. The only advantage that this system had over the pencil method was avoiding injury to the diaphragm.

There followed a period of experimentation, with many attempts to devise a telephone instrument capable of transmitting speech with sufficient loudness that a loud "ahoy" or "hello" at the transmitter would attract the attention of the person at the other end of the line. All of these attempts were failures, fortunately, as the privacy with which telephone conversations may be conducted is one of the most desirable and useful features of the modern plant.

All of these methods were obviously transitory. Although they made possible a limited use of the early private lines, they were impracticable for use with a switchboard. So, with the advent of switchboards, it became customary to call by electric bells operated by batteries. A switch was provided in the circuit so that the bell could be cut out of the line when talking. This was a great improvement, but it was not satisfactory because of the limited length of line over which batteries of a reasonable voltage could operate the bells. Furthermore, the batteries and bells needed constant attention and the cost of upkeep was prohibitive.

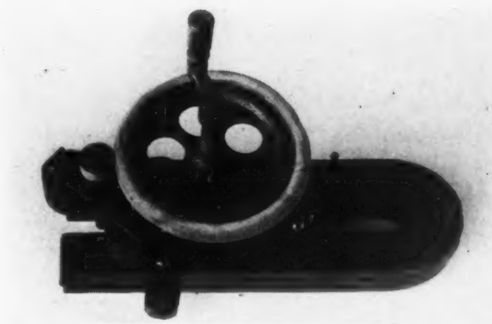
In 1878 Thomas A. Watson devised a calling system which became known as Watson's "Buzzer." It was a development from one of Dr. Bell's early harmonic telegraph experiments and utilized a vibrating reed and an induc-

tion coil. When the reed, or spring, was twanged it caused a make and break contact in the primary circuit of the coil. Then, as the secondary was connected to the line, a rasping noise was produced in the receiver of the called station. This system provided enough current to operate over moderately long lines.

Although it was more satisfactory than any previous method the buzzer was short-lived. It was succeeded the same year by the "magneto bell," so called from the machine which generated its electric power. A popular toy of that day was the "shocking machine," a hand-driven generator with permanent magnets, hence called a magneto. The ringer consisted of two coils and a polarizing magnet with an armature pivoted at its middle. Practically, the ringer is a small synchronous motor which makes one complete vibration for each cycle of alternating current from the magneto. This form of ringer permits the use of alternating current and avoids the troubles which occur in an ordinary electric bell where moving contact points must make and break the current for every blow of the clapper.

Watson's Polarized Ringer
Used in conjunction with Watson's hand generator; the forerunner of modern ringing apparatus

With the expansion of the telephone business it became desirable to have more than one subscriber on a line.



Watson's Hand Generator
Used with polarized ringer

So party lines were adopted and the ringer for each subscriber was connected in series with the line. This arrangement materially decreased the transmission efficiency of the telephone circuit because all the ringer coils offered paths through which the speech current passed to reach a distant telephone receiver.

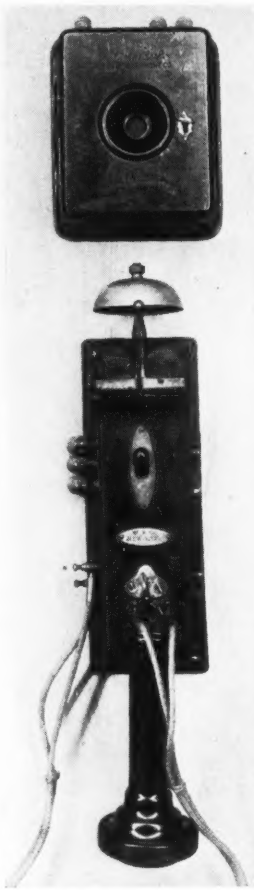
In 1890, J. J. Carty invented the bridging bell. There was provided a ringer the coils of which offered a high impedance to the talking current. When this ringer was bridged across the two wires of the line the transmission currents were little affected and yet the signalling currents could operate the bells effectively.

Subscriber's Signals

The development of the magneto generator with its associated ringer brings telephone signalling down to the present era, for this method of signalling is still used in rural systems. Since telephones of the type with

which the magneto generator is associated employ local batteries for furnishing the transmitter with current, they are generally designated as "magneto telephones" to distinguish them from "central battery telephones," which have no local battery and no magneto generator.

The magneto telephone is more generally found in rural districts, where party lines are universally used. Such lines may have from two to twelve or more stations. Each station is, in effect, a complete plant with its own battery for a power source and its own signalling apparatus in the form of a magneto generator. When a subscriber or an operator rings on such a line all of the bells respond. Such a system is "non-selective" and signalling must be by code. Each station has its individual signal formed by a combination of long and short rings. This method has several disadvantages. It may annoy subscribers and lessen privacy by giving general notice of conversations. There are also limits to the number of stations on a line because of the small current generated by a magneto.



Law Subset—Long Type

In order to overcome these disadvantages and limitations, there have been evolved several systems, each aptly named by a word picture of the fundamental idea of the method involved. They are the two-party selective, the polarity, the harmonic, and the step-by-step system.

Two-Party Selective System

This is one of the most widely used methods of selective signalling. Its fundamental idea is the fact that three circuits may be obtained from the two wires of one metallic circuit by the use of the ground as a third conductor. The bell of one station, in series with a condenser, is connected between ground and one wire of the pair leading to the subscriber's set. The bell of the other station is connected similarly with the other side of the line. Thus, each wire is used with ground to form a circuit for ringing, while the two wires together constitute a metallic circuit for talking. The central-office operator has two keys each of which grounds one side of the line and applies alternating current to the other side to ring the bell connected thereto.

This method may be expanded into a semi-selective system if it is desired to apply it to a four-party line. In that case, there are two bells on each side of the line. Both bells on a side respond to the ringing current on that circuit and the subscribers are distinguished by code, one ring for one and two rings for the other.

The Polarity System

The polarity method depends for its operation on the use of bells which will respond to a current in one direction only. The idea of selective signalling by changing the polarity—that is,

the direction of a current—was well known in telegraphy before the birth of the art of telephony. The desired result is obtained by "biasing" the armature of the bell, which means holding the armature at one end of its stroke by a spring in such a manner that it can only respond to current impulses tending to move it in one direction.

A "polarized" current is one obtained by superposing a battery in series with an alternator. When such a current flows through a biased ringer, its direct current component may aid the biasing spring, in which case the alternating component will not be able to overcome the resulting force on the armature and the bell will not ring. If the direct current flows in the opposite direction, it will oppose and in effect cancel the biasing action of the spring, and the alternating component will be free to move the armature and ring the bell. In practical use, one terminal of the alternator is grounded, and the other is connected to the negative pole of one battery and the positive pole of another battery. The other battery terminals are connected to the appropriate ringing keys to give positively and negatively polarized currents respectively.

This system in combination with the two-party method just described forms a widely-used four-party selective system. In this scheme two biased bells are connected between each of the line wires and ground. On each side of the line one bell is rung by positively polarized current and the other by negatively polarized current. The two bells on the other wire are operated in similar fashion. Four ringing keys are necessary with this system, the proper one of which serves to connect the desired side of the line with a current properly polarized.

In common battery telephones a condenser must be connected in series with each bell so as to block the flow of direct current from the central-office battery through the line relay; otherwise a steady signal would be given to the operator. When polarized current is applied to such a circuit the direct-current component is blocked by the condenser, and the alternating component is then free to operate both bells. One method used to overcome this difficulty was to connect across the condenser a resistance which would pass enough current to aid or oppose the biasing spring, but not enough to operate the central-office relay and signal the operator.

In present standard practice this resistance is eliminated in an ingenious way. A special alternating-current relay is provided in each set bridged across the line in series with the condenser. With the application of polarized currents to the line for calling any of the parties, alternating current flows through all four relays and in operating they connect the respective bells directly between both sides of the line and ground. The polarized current then operates the bells selectively as described above. Inasmuch as with this arrangement the bells are only connected to the line during the ringing period they do not interfere with the signals to the operator.

Harmonic Systems

Harmonic systems utilize the fact that a pendulum or an elastic reed so suspended as to be able to vibrate freely will have one particular rate of vibration. In this method of signalling a different type of ringer is employed. The armature and striker of the bell are mounted on a rather stiff spring so

that the moving parts constitute, in effect, a reed tongue possessing a natural period of vibration. Therefore, it may be easily vibrated by impulses of the same frequency as its natural rate of vibration while those of different frequency will not disturb it sufficiently to strike the gongs. Ordinarily harmonic systems are limited to four stations on a line and the frequencies usually employed are $16\frac{2}{3}$, $33\frac{1}{3}$, 50, and $66\frac{2}{3}$ cycles per second. These frequencies correspond to 1000, 2000, 3000 and 4000 cycles per minute.

Step-By-Step Systems

In the step-by-step method the bells are not connected to the line normally but, preliminary to ringing, any bell may be made responsive by sending a certain number of impulses over the line. Although several methods of step-by-step signalling have been successfully reduced to practice they are used very little in ordinary central-office telephony. The principles are applied, however, in train dispatching and radio telephony, and in the stock exchange ticker and other applications of telegraphy.

A typical step-by-step system illustrates the underlying principles. At each subscriber's station there are in series two electromagnets of high and of low resistance respectively, the former operating on a much smaller current than the latter. The high resistance magnet operates a ratchet wheel which carries a contact arm and a stop arm and the low resistance magnet controls another contact arm and a separate arm which locks the ratchet wheel when the desired contact is made. These contacts are adjustable and each station has a different setting.

When signalling a station the operator presses once the so-called "calling key" which sends out a large current. This single impulse of large current thus operates both types of magnets, by one releasing all the lock arms on the line and by the other moving the wheel forward one step at each station. After this another key is depressed. This throws on the line a series of weak impulses the number of which is predetermined to correspond to the setting at the station of the desired subscriber. At all the stations the contact arms move gradually. When the required number of impulses have been sent, the ratchet wheels have turned, but only at the called station are two contacts opposite each other. The operator then depresses again the calling key, sending out a strong impulse which operates the other magnet and closes the contacts of the bell circuit.

Limiting Factors

While selective signalling places limits on the number of telephones that may be served by one line, this limit is usually greater than that imposed by traffic conditions. Rural lines are often built and maintained by their users, and in order to reduce the expense they put a rather large number of telephones on each line. Although this means that they may have to wait until others have finished talking, they are not often seriously inconvenienced by the delay. Further, the cheery tinkle of the bell breaks the monotony of the long days and suggests to subscribers an opportunity for neighborly gossip. Since few calls for such lines originate outside the local central office, the cost of handling calls which receive a "busy" signal is small.

In suburban and small city areas, on the other hand, the parties per

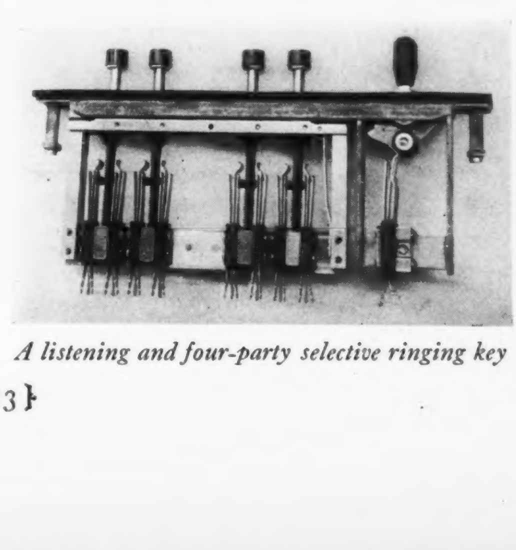
Section of a key shelf of 1880

line are limited to four. Where the calling rate is still higher, as for example business telephones, no more than two parties are connected to a line, and most of these telephones are served by individual lines.

Ringing Equipment on the Key Shelf

Associated with every cord circuit there must be some means for starting and stopping the ringing current. In the simplest case this is merely a push-button key which disconnects the line from the rest of the circuits and connects it to the ringing generator. In magneto and toll boards a ringing key is associated with each cord of the pair; in most other boards, only with the calling cord. Two-party selective ringing may be given in two ways: by two ringing keys in the cord circuit, each applying ringing current to its side of the line; or by using the so-called "jack per station" switchboard. In the multiple of this board there are two jacks for each party line and the talking wires are interchanged when they are cross-connected at the main distributing frame. Hence applying ringing current to the "tip" conductor of the cord circuit will apply it to one or the other line wires according to which of the two jacks is plugged into. This system simplifies the ringing circuit and will effect an overall saving in areas where only a few party lines are served. It also gives no indication of the class of service.

For four-party selective ringing four keys are usually provided for each cord circuit. A simple mechanism locks down the last key to be pressed, as an indication to the operator. Where ringing is controlled only by the operator the last key to be pressed locks half-way down as an indication to the operator to relieve her memory, in case a re-ring is necessary. All the later "B" boards and some "A" boards have "machine" ringing in which the operator merely sets up a relay circuit. When most of the lines are individual, the B-operator glances at the keys to be sure that "party W" is depressed, and plugs into the line jack. In the latest type of machine-ringing boards, a common set of ring-



A listening and four-party selective ringing key

ing keys controls the ringing on all of the cord circuits.

In contrast to the signals just discussed is the so-called "audible ring-back." It was introduced because of the psychological effect on the calling subscriber of receiving an indication that his call was being attended to. Traffic observations show a large decrease in recalls by the subscriber to ask the operator to "ring them again." The most common circuit involves a small condenser bridged across the ringing key so as to allow the higher-frequency harmonics of the ringing current to flow to the calling subscriber.

Power for Ringing

In the smallest magneto offices, ringing current comes from a hand generator mounted under the key-shelf. Where traffic keeps the operator busy, she is relieved from turning the generator crank by the provision of a pole-changer. This device is a relay with a heavy armature whose period is twenty cycles a second. It is kept vibrating by a number of Edison primary cells, and auxiliary contacts on the armature reverse the polarity of a battery of dry cells. Two pole-changers are used in the smallest common-battery offices; they are driven from the 24-volt battery, and they reverse current from this battery through the primary of a transformer which delivers a suitably higher voltage to a low-pass filter. In larger offices, one pole-changer and one motor-generator outfit are used; in the still larger offices, two or more motor-generator outfits. These consist of a motor driving a double current generator. From a commutator at one end of the armature comes direct current to excite the field and when desired to operate the coin mechanism in public telephones; from a pair of slip rings at the other end comes twenty-cycle alternating current—usually at eighty volts—for ringing. Another commutator interrupts current from the central-office battery to give the "trouble" and "busy" tones. A slow-speed shaft driven by a worm and gear from the main shaft carries a number of commutators to control currents for intermittent ringing, "busy flash," and other signals.

To guard against failure of the public service power by which these machines are driven, one ringing machine is always equipped with a motor which can be run from the central-office battery. In some of the largest offices, both motors are built into the machine. Then if the outside power fails, a relay at once throws the other motor onto the central-office battery and the machine never stops.

All who are interested in the trend of modern atomic theory will welcome the announcement that the Nobel prize for physics for 1924 has been awarded to Prof. Manne Siegbahn of Upsala. His most notable researches, and those for which the award has been made, have been in X-ray spectroscopy. Since Moseley's first measurements, the technique has been improved to such an extent that it is now possible to measure wave-lengths in this region of the spectrum to six significant figures. This advance is due, almost entirely, to the work of Prof. Siegbahn. In addition to these high precision measurements, he has made an exhaustive study of the soft radiations which lie between the ultra-violet and the ordinary X-ray region. From "Nature," November 21, 1925

Our Canadian Correspondence

THE Transmission Engineer of the Northern Electric has many friends in the Laboratories and they will be interested in the following letter written by him to Burton W. Kendall. In this letter Mr. Vennes refers to the statement on page 152 of the November RECORD that "The Australians compliment themselves upon the fact that, with the exception of the United States, Australia is the only country in the world operating long-distance telephone traffic on the carrier-wave principle." The Sidney "Daily Guardian," for example, said in its issue for September 10th: "With the exception of the United States, Australia will be the only country in the world operating long-distance telephone traffic on this system."

Actually, the carrier-current systems developed for the Bell System have been made available to other countries through the International Western Electric Company. The Australian installation is not the only installation of this Western Electric equipment for there are installations in Canada and Brazil. The Australian newspapers were laboring under a misapprehension in their comments. The article in the RECORD, however, to which Mr. Vennes refers, being intended to show the attitude of the Australians toward their new equipment, was made up of direct and indirect quotations from their newspapers; and hence no criticism of their comments entered the article.

Mr. Vennes writes:

"Dear Kendall:

I have read with great interest the articles in the December issue of the Record, dealing with carrier-current systems. I was particularly interested in noting how successfully the Australian project "went across" and more so on account of my early connection with that job. Mr. Jammer is certainly to be congratulated on the successful way in which he has made the carrier "talk for itself."

There is one point, however, on which I must comment, and if only the Editor of the Sydney "Daily Guardian" were not so far away I might be able to vent my feelings in the proper direction. Does Australia forget that she has a sister country by the name of Canada and that carrier-current telephones have been in successful operation in that country for over four years? or is Canada considered to be a part of the United States as far as Australia is concerned? I feel sure our Alberta friends would beat it across the Pacific with six-shooters if they were shown the "Guardian" article.

How about our friend Mills who burnt midnight oil in writing up operating instructions for the Edmonton-Calgary System? He should have challenged the statement of the "Guardian." How about your good self who knows very well that the Edmonton-Calgary System has band filters?

In writing this I am trusting that you will have checked your razor with the doorman when I see you next time—but I simply had to get this off my chest. I feel better already. I have heard several cutting remarks from some of our people here and hence the reaction. Only dead balls refuse to bounce.

Your article on "Carrier-Current Telephone Systems" is very interesting, and I note with much pleasure the honorable mention you have given me. Memories of Maumee come to me quite often, and even Baltimore leaves no uncertain recollection of pleasant work. Even the memorable Sunday morning on which the System was to be cut into service can be looked back on with fond recollections.

During the recent conference of building and equipment engineers held by the American Telephone and Telegraph Company, about forty-five of the visiting engineers, at the invitation of Amos F. Dixon, made an inspection trip through the Laboratories. The visitors, who represented the American Telephone, Western Electric, and associated telephone companies, were divided into small groups and guided through the various laboratories by supervisors of our Systems Development Department.

Harvey Fletcher spoke to the students and faculty of the Cornell University School of Electrical Engineering on "The Physical Nature of Speech," and to the Ithaca Section of the A.I.E.E.

"Electrical Transmission of Speech," a motion picture film, was presented by the Laboratories at the December 9 meeting of the New York Electrical Society. The meeting was given over to a discussion and demonstration of the use of motion pictures as a pictorial record of the progress of science and industry.

Karl K. Darrow recently spoke before the physics colloquium of Harvard University on researches in thermionics, photoelectricity, and the scattering of electrons by atoms.

Lectures before the student body of Lehigh and before upper-class engineering students at Lafayette were given on November 12 by John Mills, speaking on the "Choice of an Engineering Career." At Lafayette there was also a showing of the films "The Electrical Transmission of Speech" and "Through the Switchboard."

John J. Gilbert delivered an address before the New York Alumni Chapter of Gamma Alpha Graduate Scientific Fraternity on "Putting a Kick into Submarine Cables."

Francis F. Lucas described to students of the Harvard Engineering School the technique of high power photo-micrography of metals, and discussed the structure of steel under very high magnification.

The National Academy of Sciences and the National Research Council of the United States have announced the forthcoming publication of International Critical Tables of Numerical Data of Physics, Chemistry and Technology.

The material for the Tables has been collected and critically evaluated by some 300 cooperating experts, including chemists, physicists, and engineers of the United States and many foreign countries. Among the contributors is Harvey Fletcher of Bell Telephone Laboratories. His contribution was numerical constants of speech and hearing. The material which he furnished is essentially that contained in his article "Useful Numerical Constants of Speech and Hearing" which was published in *Bell System Technical Journal*, Vol. IV, No. 3, of July, 1925. Mr. Jewett and Mr. Craft were trustees for the publication of these tables.

Sergius P. Grace delivered an address on "Research in the Bell Telephone Laboratories" before the Rochester Section of the A.I.E.E.

I Give and Bequeath

"*As to all my worldly goods, now or to be in store,*

I give them to my beloved wife, and hers evermore.

I give all freely; I no limit fix;
This is my will, and she's executrix."

Such was the unique last will and testament said to have been drawn by one Smithers, a London lawyer, in which he made provision for the disposition of his property upon his death. In the past many means have been used for the disposition of property by will and many odd ways have been devised; but, as the making of a will is now generally governed by statutory requirements, the odd and novel method is not usually a safe one to employ.

Many years ago the matter of making a will was considered an omen of approaching death, but this superstition no longer prevails. The prudent man or woman looks upon the making of a will as similar to any other business transaction except that in the case of a will it does not become effective until the death of the testator.

Everyone admits the necessity of making provision for his or her dependents, but many, while they have good intentions in regard to the making of a will, for one reason or another put the task off too long. Failure to make a will results in the distribution of property in accordance with the laws of the state; and the law will, in such cases, make a will for the person who fails to make one for himself or herself. The results in cases of this character are that the distribution of the property at death is not made in the manner or proportion which always works for the best interests or needs of those dependent.

For example, suppose a man in New York died without a will and left an estate of $10,000.00. If he left surviving him a wife and one minor child, the estate would be divided, one-third to the wife and two-thirds to the minor child. It would be necessary to apply for letters of administration of the estate, for the administrator to file a bond covering the faithful performance of his duties as such administrator, and to arrange for the appointment of a guardian who would be in charge, during the infancy of the minor, of the person and of the estate of the minor. All these proceedings would involve expense much of which would have been avoided if a will had been made and provision inserted for the payment of the legacies in the proportion desired, for the waiving of the bond of the executor, and for the nominating of a relative or friend who would act without expense as guardian of the minor.

The administration of an estate disposed of by will is through an executor, or an executrix if a woman handles the estate. The estate and the person so charged with this responsibility are under the jurisdiction of the Surrogate or Probate Court, to whom accountings covering the management of the estate must be made from time to time. In many states at least one

year must elapse before an estate can be finally settled.

The general legal requirements to be considered in the preparation of a will are:

1. The person must be competent to make a will.
2. It must be in writing, signed, sealed, and attested before at least two witnesses who must not be legatees.
3. An executor or executrix must be appointed.

The preparation of a will, like any other business document, should be accomplished only after careful consideration and after competent advice is obtained. The services of a lawyer are desirable not only so that the body of the will may properly reflect the testator's intentions as to the disposition of his property but also for the purpose of ascertaining that the statutory requirements are adhered to with respect to the execution of the will.

On the Road During November

IN the September issue of the RECORD there was described in "Our Far-Flung Outposts" some of the work carried on outside of New York by members of the Laboratories who have more or less permanent assignments in the field. In addition to these "outposts" many occasions arise when our engineers make trips of short duration on special assignments or in connection with their usual duties.

These short absences from West Street are usually one or another of four kinds. In the first place they occur in the co-operation of our engineers with those of the American Telephone and Telegraph Company in the field trials of recently designed equipment. In the second place and with more frequency they arise from the need of co-operation and conference with the engineers at Hawthorne in connection with equipment which the Western Electric is to manufacture. A considerable number occur as part of the engineering services which were mentioned in "Who Pays Our Salaries" (RECORD, Vol. I, No. 2) as performed by the Laboratories for the Western Electric Company. These include all absences for the engineering and installation of public address systems, radio broadcasting stations and power line carrier. In addition another group of absences from New York are occasioned by attendance at meetings of professional and scientific societies and by the acceptance of invitations to speak on technical subjects before technical societies and university audiences.

As an example of the range and variety of these outside contacts of members of the Laboratories the RECORD presents a brief statement as to the travels and business of some of the men who were on the road during the single month of November.

From the Apparatus Development Department L. W. Conrow was in Chicago, Milwaukee, Champaign, and Des Moines, making surveys for prospective public address system installations. He was also in St. Louis completing work on a public address

system for the Hotel Coronado, where T. L. Dowey assisted in the final tests. R. E. Kuebler in Philadelphia demonstrated to Mr. Shibe, at the Shibe Ball Park, the application of the No. 1 Public Address System for announcing athletic events. F. M. Ryan is in Hawaii in connection with a radio survey to check the feasibility of connecting the telephone systems on the various islands by means of radio toll circuits, and to determine the general requirements to be met by the radio transmitting and receiving apparatus which would be required.

P. H. Evans made a three weeks' tour of inspection of some of the broadcasting stations using Western Electric equipment. The stations visited were WWJ (1 KW), WCX-WJR (5 KW), Detroit; WENR (1 KW), WQJ (500 watts), WLS (5KW), Chicago; WCBD (5 KW) Zion; WCCO (5 KW) Minneapolis; WOC (5 KW) Davenport and WSAI (5 KW) Cincinnati. On the Pacific Coast D. H. Newman was supervising installation of broadcasting equipment (500 watts) for Nichols and Warinner, Long Beach; Pasadena Star News (1 KW), Pasadena; and the First Avenue Baptist Church (500 watts), San Jose.

W. L. Tierney and J. C. Herber in Chicago supervised the installation of 1 KW broadcasting equipment for the *Chicago Daily News*. This equipment replaces the 500 watt equipment installed in September, 1922. Mr. Herber later made surveys for proposed installations at the Universities of Illinois and Notre Dame.

P. A. Anderson returned from Jacksonville, Florida, where he supervised the installation of a 1 KW broadcasting equipment for that city. J. C. Crowley supervised the completion of 1 KW broadcasting equipments for Larus Brothers, Richmond, Virginia, and M. M. Johnson and Company, Clay Center, Nebraska. C. Flannagan in Baltimore supervised a 5 KW installation for the Consolidated Gas, Electric Light and Power Company. J. S. Ward expects to complete the installation of the 5 KW equipments for Sears, Roebuck and Company, Chicago, and the Bankers Life Company, Des Moines, and to get back to New York before Christmas.

L. B. Cooke installed a power-line carrier system on the lines of the Northern States Power Company between Minneapolis and Eau Claire. W. V. Wolfe was investigating carrier transmission characteristics on power-lines between Toccon and Stevens Creek, Georgia. R. D. Gibson and J. B. Irwin were installing power-line carrier telephone equipment for the Augusta-Aiken Railway and Electric Company, Georgia. D. C. McGalliard was similarly engaged for the Alabama Power Company between Magella and Sheffield, Alabama.

W. T. Booth, H. H. Glenn, E. B. Wheeler, F. F. Lucas, H. N. Van Deusen, J. T. Butterfield, J. R. Townsend, W. Fondiller, R. E. Schumacher, J. E. Harris, R. L. Burns, C. D. Hocker, W. C. Redding, and C. H. Matthewson were at Hawthorne discussing questions of apparatus design. R. H. Hart, R. M. Moody and W. C. Miller attended service conferences on various types of apparatus.

C. R. Steiner has been in Hawthorne studying the manufacture of step-by-step central office apparatus.

H. A. Anderson attended a meeting in Cleveland of the American Society for Testing Materials. Together with H. T. Martin and H. N. Van Deusen he visited Camden, New Jersey, to discuss improved designs for parts of the Victor talking machine.

H. C. Harrison spent several days

at Camden in the laboratories of the Victor Talking Machine Company.

A. B. Sperry, also of the Systems Development Department, has been at Hawthorne in connection with the manufacture of step-by-step machine switching equipment. J. A. Mahoney and T. C. Campbell of the Equipment Development group are spending three months at Hawthorne on a special training program planned to acquaint them with manufacturing methods and the work of the Switchboard Planning Division.

W. C. Jones of the Research Department has been in Boston. R. R. Williams went to Huntington, West Virginia, for a meeting of the Club of Industrial Research Directors and also attended the annual meeting of the American Institute of Chemical Engineers at Cincinnati.

J. A. Becker presented a paper to the American Physical Society at its Chicago meeting, which was also attended by K. K. Darrow.

Radio tests took G. Thurston, F. A. Hubbard, F. B. Llewellyn, S. Wright, E. G. Ports, G. Thurston, E. Bruce, R. A. Heising, J. G. Chaffee, J. F. Farrington, J. C. Schelling, F. R. Lack, and E. Kraut to various parts of the country.

P. B. Flanders has been assisting the Victor Company of England in applying the latest improvements in the phonograph art to their product; and T. C. Kinsley is assisting him.

A. A. Oswald and H. R. Knettles are in England assisting the International Standard Electric Company by supervising the installation and final test of the Rugby Transatlantic Radio Station of the British Post Office.

Several other research men, including W. A. Knoop, W. S. Gorton, W. Orvis, J. F. Wentz have been working in England on permalloy-loaded cables with G. A. Anderegg.

From the Patent Department, E. W. Adams is in London in connection with patent matters.

W. H. Matthies made a trip to Scranton with Mr. Lysons of the Northern Electric Company and Mr. Brockwell of the staff of the Commissioner of Telephones of Manitoba. The trip was made in order that Mr. Brockwell might see the working of the 200 point line finder in the Scranton trial. The Manitoba Administration is considering equipment using similar apparatus and Mr. Brockwell desired to familiarize himself with its characteristics.

Many members of the Inspection Engineering Department are located outside of the city in the regular course of their business. Two changes in location which were in the nature of promotions occurred when on December first W. K. St. Clair, formerly Local Engineer of the New York district, became Local Engineer of the Philadelphia district, and J. A. St. Clair was appointed Local Engineer of the New York district.

Western Electric Incorporates Supply Department

THE morning papers of December 23, carried the interesting announcement that the electrical supply business of the Western Electric Company had been segregated from the telephone manufacturing business and incorporated under the name "Graybar Electric Company."

Charles G. DuBois, President of Western Electric is Chairman of the Board of the new company; Albert L. Salt, formerly Vice-President in charge of purchases and traffic of Western Electric, becomes President; Frank A. Ketcham, General Manager of the Supply Department, becomes Executive Vice-President; George E. Cullinan, General Sales Manager, becomes Vice-President in charge of sales; Leo M. Dunn, General Merchandise Manager, becomes Vice-President in charge of merchandising and accounting; Elmer W. Shepard, General Credit Manager of Western Electric has been made Treasurer; and N. B. Frame of the legal staff of the Western Electric Company has been made secretary of the new company.

The board of the new company includes George E. Cullinan, Albert L. Salt, Charles G. DuBois, Frank A. Ketcham, Leo M. Dunn, R. H. Gregory, Controller of Western Electric, Howard A. Halligan, Vice-President of Western Electric; George C. Pratt, General Attorney of Western Electric, and William P. Sidley, Vice-President and General Counsel of Western Electric.

The name of the new company is derived from that of Gray and Barton, the partnership formed between Professor Elisha Gray and Enos M. Barton in 1869 to manufacture electrical equipment. The small shop of Gray & Barton, which produced telegraph apparatus, call boxes, fire and burglar alarms, developed into the Western Electric Company. It is believed that this is the first instance where a corporation after such a lapse of time and a period of such tremendous growth has reverted to its original designation for a corporate name.

Changes have been made in the organization of Western Electric necessitated by creation of the new company. Jay B. Odell, Assistant to the President of Western Electric Company, becomes Vice-President, succeeding Mr. Salt. Mr. Odell will be in charge of purchases and traffic. F. L. Gilman, manager of the Kearny works, becomes Treasurer of Western Electric, succeeding J. W. Johnston, who is retiring after thirty years of service. C. G. Stoll, manager of the Hawthorne works in Chicago, will be general manager of manufacturing, in charge of all manufacturing in addition to his present duties.

R. C. Dodd, assistant manager o- the Kearny works, has been appointed works manager at Kearny under Mr. Stoll.

As a result of these changes, Mr. Salt, Mr. Johnston and Mr. Ketcham are replaced as directors of Western Electric by Mr. Odell, Mr. Stoll and George C. Pratt, the company's general attorney. The changes are effective January first.

Club Notes

David D. Haggerty, Secretary

Club Elections

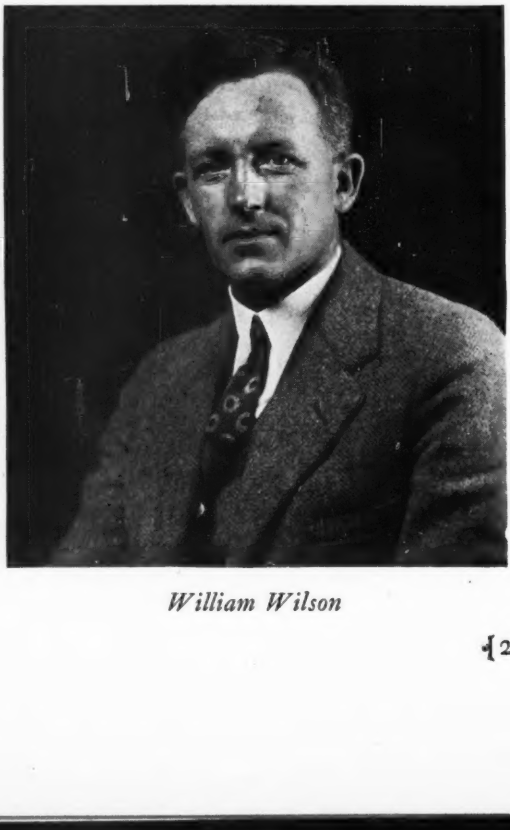
As a result of the recent elections the following candidates have been elected to office:

For President	William Wilson
For First Vice-Pres.	Daniel R. McCormack
For Second Vice-Pres.	Marion G. Mason

Departmental Representatives

Apparatus Design	L. B. Eames
Patent Inspection	G. Heydt
Shops	J. Motley

No election for mayor of New York City was ever harder contested or better managed than the fights carried on by the campaign managers for the various candidates. The popularity of all the candidates made the election extremely close, and during the count of ballots some of the elections were not decided until all votes were in. A total of 3100 ballots was cast.



William Wilson

Membership Cards

Membership cards are obtainable by either calling at room 108 or telephoning extension 542. Besides being certificates of membership these cards are very valuable as a means of identification when taking advantage of any of the Club's privileges.

Daniel R. McCormack

Club Pins

During the past few months the club has enrolled over 1,000 new members. In David D. Haggerty's office there is available a supply of very attractive club pins. They are of ten carat gold with blue enamel face, gold lettering and safety catch; and the price is $1.65. All members, new and old, are invited to inspect these pins.

Chess Activities

If the results of the chess matches which have been played so far this season may be taken as any indication, the Potter trophy will have the West Street Trophy Case as its permanent home. Again our chess players are carrying off the honors in the championship matches of the Commercial Chess League of New York City. On November 21, captained by F. A. Voos, the West Street team met and defeated the repre-

sentatives of the Henry L. Doherty Company four straight games. On December 5, they repeated the performance by defeating the McGraw-Hill Publishing Company 4—0. On December 14, they won three out of four games from the Western Union representatives.

The team will play the Chase National Bank, New York World, Guarantee Trust Company, New York Edison Company, Tidewater Oil Company, and Brooklyn Edison Company, in the order mentioned.

The Club's own tournament for "A" and "B" class players is now in progress. Four groups of five men each are entered in the first Round Robin contest. From the result of these matches will be determined the grouping for the second contest which will start early in January.

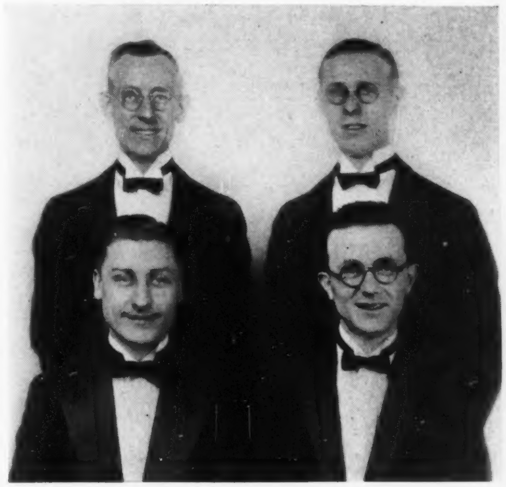
The ladder tournament for class "C" players is now under way with thirteen contestants. Those who finish at the top are entitled to compete in the final Round Robin tournament which will be held to determine who shall represent West Street in the telegraph chess match with Hawthorne.

Miss Marion G. Mason

Basket Ball for Men

The basket ball league for men started the 1925-26 season on Tuesday Evening, December 8, when President Kendall threw up the ball which started play in the first league game. The game was between the teams representing Toll Circuit and Apparatus Design. Toll Circuit's speedy and wide-awake quintet staged a sensational rally during the last few minutes of play and pulled out a victory over Apparatus Design after apparently being beaten. The final score was 23–18.

Two games are played every Tuesday and Friday evening, starting at 5:30, at Labor Temple, Fourteenth Street and Second Avenue. Club members are invited to attend.



The Colvoy Quartette: F. M. Costello, F. von Schlichten, F. F. Lee, R. P. Yeaton

Glee Club Quartette

The quartette representing and made up of members of The Bell Telephone Laboratories Glee Club is working on a program of favorite songs of long ago; songs which, though old, will always be enjoyed. The personnel of this quartette, known as The Colvoy Quartette, is as follows: F. F. Lee, First Tenor; R. P. Yeaton, Second Tenor; F. M. Costello, Baritone; and F. von Schlichten, Bass. This organization has broadcast on numerous occasions through WOR, WGY and WEAF, and the program of old songs is being pre-

pared to fill a request for this class of song. At the dance held recently by The Bell Laboratories' Club at the Pennsylvania Hotel the quartette sang a number of selections and was received with great enthusiasm.

Basket Ball for Women

The women of the Club are organized into four basket ball teams which represent Equipment, Transcription, Patent, and Research Departments, respectively. These teams are playing three series of games: the first on Thursdays in December, the second during January, and the third in February. Games start at 5:30 p.m. at Friends School, Stuyvesant Square. It is hoped that Correspondence Files, winners of last year's championship, will be represented in the January series.

Swimming Meet for Women

On January 20, the club will present something new—a swimming meet for women, to be held at the Carroll Club, 121 Madison Avenue. It will include swimming and diving contests for Club members and a swimming and diving exhibition by the Volunteer Life Saving Corps of America. Although the contests are for the girls only, members and their guests are welcome. No entry fee nor admission charge.

All members, and especially those who asked for the meet, are urged to file entry blanks at once with Mr. Haggerty or Miss Hence.

Women's Bridge Parties

Each Wednesday evening at 6 o'clock our Club women hold a card party in the rest room. Miss Murtagh, who is in charge, invites all the women of the building to take part. She is glad to plan for a new player. Players are assessed a small sum for the prizes.

Sewing Classes

"Women's Wear" hints that this year's display of feminine apparel will exceed in charm, grace, and simplicity of line the gowns of any other season. The very latest are being designed and created by the girls of the Laboratories under the skillful guidance of Mlle. Bowman. We are told the designs include simple frocks for office wear, party frocks, and evening gowns for the more formal occasion. Mlle. Bowman's studio classes are in session every Thursday evening and the fee is $4.00 for eight lessons.

Ervin E. Hence